Determining Field Conditions for Mine Impact Burial Studies

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LONG-TERM GOAL

The long-term goal of this work is to develop and deploy a set of tools that can be used to determine *insitu* values for certain sediment geotechnical properties that are needed when predicting the potential for burial when mines impact the sea bottom.

OBJECTIVES

The principal objective of this work has been to develop a set of mechanical, remote-sensing tools that will permit the determination of the main geotechnical variables that control mine embedment in the bottom. These properties include the porosity and undrained shear strength of soft, fine-grained cohesive sediments and the relative density of coarser granular sediment such as beach sand.

APPROACH

Over the past several years our field work in Sediment Acoustics (N00014-94-1-0258) has led to the development of a number of remote-sensing tools that have direct application to the problem of mine burial prediction. As an example, the penetration resistance measured by several different types of probe we have developed is directly related to the bearing capacity of the sediment which is of prime importance in studies of mine burial in the seafloor. These probes include an expendable bottom penetrometer, XBP, PROBOS, a modified version of the Canadian STING penetrometer and a quasistatic penetrometer STATPEN that measures both cone and sleeve penetration resistance to a depth of 2 meters into the sea floor. The XBP probes have been used to map critical areas in two recent NATO exercises aimed at Rapid Environmental Assessment (Stoll and Akal, 1999) and various versions of STATPEN have been built for NATO, Saclant Undersea Research Centre and for the Naval Research Lab, Stennis Space Center.

STATPEN utilizes a cone penetrometer of standard size and shape (i.e. Amer. Soc. Testing and Materials (ASTM) std 60 degree cone, 10 square centimeters of crosssectional area and a 2 cm/sec penetration rate) supported by a weighted, 4-legged frame that rests on the sea bottom during deployment of the cone. The penetrometer frame is first lowered to a depth about 1or 2 meters above the bottom and then lowered the rest of the way at test time. Our basic unit is capable of pushing the cone to a depth of 2 m with a maximum thrust of 1000 lbs. The unit is easily dismantled for shipping and has been used in the Mediterranean and the Baltic for ground-truthing a number of acoustics experiments and in the waters around New York Harbor to measure the thickness of sand caps over dredge spoil areas. Because of the wealth of data available in the literature for tests performed with a ASTM standard cone penetrometer, in most cases, undrained shear strength for fine-grained cohesive

sediment can be directly estimated from the cone resistance using various correlations that have been published. A view of an early version of STATPEN suspended in the water column is shown in the figure shown below.

XBP is system using expendable probes of the same size and shape as the standard XBT (Expendable Bathythermograph) that is extensively used by the Navy and other marine agencies to measure temperature.. However in the XBP, instead of temperature measurements in the water column, deceleration is measured during impact and penetration of the bottom and this data is then integrated to determine depth of penetration and the penetration resistance of the sediment. The characteristics of the impact signature are then analyzed to obtain shear strength, sediment type and other properties based on a large data base that has been collected over the past few years at SACLANT Center and Lamont-Doherty Earth Observatory (Stoll and Akal, 1999). A contour diagram showing decelerations measured during an XBP survey is shown in the figure below.

PROBOS is an improved version of the Canadian "STING" penetrometer with the same dimensions and shape as the STING but with additional capability of being able to display both the force on the tip as well as the deceleration of the unit without the necessity of recovering the probe and downloading the data with each deployment as is the case with the STING.

WORK COMPLETED

During FY 01 we rebuilt STATPEN so that it is now able to measure both tip and sleeve penetration resistance since some of the newer papers in the literature use both of these parameters to classify the sediment as to type and geotechnical properties. As a result of this change it was also necessary to modify the software for data acquisition and plotting. The newly modified unit has been tested in the lab and is now ready for field reconnaissance work that is scheduled for October 2001 in conjunction with the upcoming mine burial experiments.

Software for the XBP has been improved and there is now a program that allows the principal binary data file to be scanned and any anomalous spikes or other glitches to be ignored in the analyses that are used to classify the sediment and determine its properties. The new program also allows the data in the vicinity of bottom impact to be saved in an ascii file for additional analysis
as to penetration rate, etc in a spreadsheet-type program. We have also built a recoverable version of the XBP for shallow water use that can be recovered and reused many times.

RESULTS

The updates and modifications of the XBP, STATPEN and PROBOS are nearly complete and 48 XBPs have been procured, mainly for the preliminary survey scheduled for mid October 2001.

IMPACT/APPLICATION

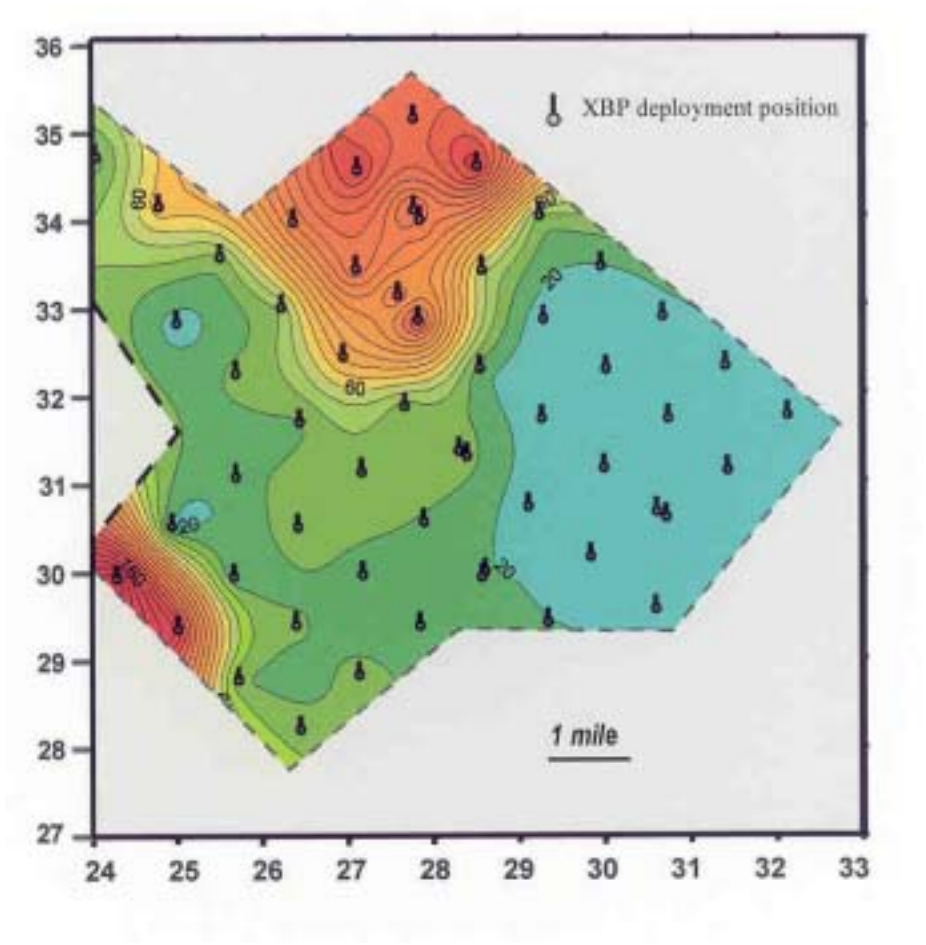
We expect the results of the preliminary geotechnical survey scheduled for October 2001 to produce a contour map of the penetration resistance to be expected in the general area where the mine-drop experiments are planned based on the XBP results. In addition STAPEN and PROBOS will be deployed in limited areas which appear most favorable for the main experiments to check for vertical inhomogeneities (i.e. sand layers,etc). We will also compare results of these tests with vane shear

measurements made by others to check on the consistency of shear strength predictions based on the XBP data. This information together with the results of the bottom-penetrating sonar survey will act as a guide in choosing the final site for the experiments.

TRANSITIONS

In 1999 we prepared an XBP evaluation package for the Naval Oceanographic office composed of software, an electronic interface board and a users manual for use on board NAVO ships. As a result of their initial trials of the XBP they ordered eight addition systems for use on their survey vessels and on Navy mine hunting ships. These systems were delivered in July, 2001.

Quasistatic penetrometer (STATPEN) suspended in water column about 2m off bottom



Contour diagram of maximum deceleration from XBP; red = >60g green = 60>g>20, blue = <20g.

REFERENCES

Stoll, R. D. and T. Akal 1999: XBP-A tool for rapid assessment of seabed sediment properties, Sea Technology, Vol 40, No. 2, pp. 47-51.

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